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INFLUENCE OF HYDROLOGIC REGIME ON ZOOPLANKTONIC DIVERSITY OF HARREZA DAM (Haut-Cheliff) AIN DEFLA ALGERIA

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ABSTRACT

Dam of Harreza is located in meadow of high Cheliff (Algeria) with semi-arid climate. It is characterized by a weak hydraulic activity and irregularity of waters distributions. During two years' study, average monthly volume passed from 3.68±1.02 Hm^3 in 2009 to 11.65±4.58 Hm^3 in 2010. Measuring of temperature, dissolved oxygen and zooplanktonic samplings had been conducted in 5 stations spread between shores and pelagic zone. Variation of hydrologic regime recorded during both years had not affected the spatiotemporal evolution of the temperature. Growth of contents in dissolved oxygen had been recorded during the second year (2010) in keeping with water level growth.

Structural study of zooplanktonic populations allowed noting that specific richness had declined passing from 26 in 2009 to 24 in 2010. That is translated by disappearance of 3 species (*Chydorus sp.*, *Polyarthra dolichoptera* Idelson, 1925 and *Neolovenula alluaudi* Guerne & Richard, 1890) and appearance of specie non inventoried in 2009 (*Epiphanes senta* O.F. Müller, 1773). In terms of time, relative abundance did not show any significant difference, when from spatial level, differences are noted between stations. Hydrologic regime of Harreza Dam keeps abundance of zooplanktonic population when diversity of the last ones is influenced.

KEYSWORDS: Hydrology, Dam, Temperature, Dissolved Oxygen, Zooplankton, Abundance

INTRODUCTION

In Algeria, dam's lakes, represent an important part of hydric reserves intended for agriculture, supplying in potable water and to development of fishing and aquaculture (Boudjadja et al., 2003 ; Bacha et al., 2007 ; Kara, 2012). Water reserves of these ecosystems with hot climate distinguished by hydrologic, physicochemical and particular biologic characteristics (Loudiki, 1990; Cherifi et al., 2002; Cherbi et al., 2008) are threatened in their qualities and their quantities, because of drought and strong temporal irregularities of precipitations (Remini et al., 2009). Water level drops are known for disturbances and for unbalanced physico-chemical quality which cause in theses aquatic ecosystems (Al Faidy et al., 1999; Rojo et al., 2000; Sadani et al., 2004). Among biologic factors which are affected, zooplankton population are one of components the most sensitive of aquatic trophic system (Platt et al., 2003; Berger et al., 2010), for they are determining by their key role in functioning and dynamic of aquatic ecosystems, contributing to the transfer of energy fixed by the autotrophs at the higher trophic levels (Haberman, 1998). They also represent the most important protein source for fish and predator invertebrates (Balvay, 1990; Nogrady et al., 1995; Piasecki et al., 2004; Brassard, 2009). The aim of this work is to value, on two consecutive years (2009 and 2010), impact of hydrologic regime on

structure and spatiotemporal distribution of zooplanktonic population of Harreza dam. The small area and weak hydraulic activity made of this dam, a chosen site for this study.

MATERIAL AND METHODS

Study Site

Harreza dam (N37°59’34’’, E1°57’46’’) is situated in the meadow of high Cheliff (Algeria) with semi-arid Mediterranean climate (Figure 1). It is found on Harreza river, in district of Djelida (wilaya of Ain-Defla), at 315 m altitude and about 120 km to South-West of Algiers. This is a tank of regulation and compensation of waters of Cheliff River (Table 1). It has been brought in service in 1984 to strengthen irrigation of high Cheliff parameter with affected yearly volume of 23 hm^3. Except the weak flow of Harreza river on which the dam is located, main water contributions come from Cheliff River by derivation and are made with help of pumping during flood periods. In spite of its surface of 620 ha and its initial capacity of 70 $hm^{3,}$ those last years, Harreza dam is distinguished by weak water levels induced by pumping absence which had been abandoned since 2007 because of expensive cost of electric power. Filling up is made only by contributions of Harreza River.

SAMPLINGS AND MEASURES

Five samplings stations (Figure 1) were put in place and spread between the right shore (S1 and S3), and the left shore (S2 and S4) and in full water (S5). In each of those 5 stations, measures and samplings were made monthly from January 2009 until December 2010. Temperatures (°c), and dissolved oxygen (mg/l) are measured with help of multi-parameter analyser (of type Multi 340 i Set WTW) to 1 m from water surface. For zooplankton study, we used a plankton net mesh of 80µm. Each sample is kept in formalin at 4%, then observed for identification (specific composition) and counting. Calculations of relative abundance, specific richness, frequencies of occurrences and indexes diversity of Shannon-Weaver (H’), of Simpson (D), of Hill and of Pielou (J’) have been made as described in works of Daget (1976), Barbault (1992), Ramade (2003) and Boulinier et al. (1998). Index of Shannon H’ is minimal when it is equal to zero which that means when sampling contains only one specie, it is maximal (theoretically unfinished) when all individuals belong to different species. Index of Simpson (D) is linked to abundance variations between dominating species.

When (1- D) tends towards value of 1 it is to indicate maximal density and value of 0, it is to indicate minimal density. Index of Hill allows a proportional abundance measure associating indexes of Shannon-Weaver and of Simpson. As index of (1-Hill) is closer of value 1 as the diversity is maximal. Index of Pielou (J’) allows estimating distribution of dominating and dominated species. Index J’ varies from 0 to 1, it tends towards 0, when quasi totality of population is focused on one or two species (one or two dominating species), it is of 1 when all species have the same abundance.

STATISTIC ANALYSIS

In order to study spatiotemporal variations of zooplankton, parametric hypothesis tests or non parametric have been applied. A Principal component analysis (PCA) has been applied to highlight existing correlations between different studied factors. Calculations have been conducted with two software Excel stat version 2009 and R (R Development Core Team 2010).

RESULTS

Hydrologic Regime

Recorded water reserves during both years are very different (Table 2). The year 2009 (first year) is characterized

by monthly average volume 3. 68±1, 02 Hm3 with minimum of 1.643 Hm3 in September and maximum 5.96 Hm3 in December. However, year 2010 (Second year), is pronounced by monthly average volume of 11.65±4.58 with minimum of 4.239 hm3 in December and maximum of 18.826Hm3 in May.

Temperature Regime

Water temperature statements of Harreza dam present the same evolution in the time and the space (Table 3). None significant difference is noted between stations and between both years (p-value=0.9). Weakest temperatures are recorded in March of both years: 8.9°c in station S5 (2010) and 9.1°c in stations S3 and S5 (2009). Higher temperatures are recorded in August in station S2:29.7°C (2009) and 28.4°c (2010).

Oxygen Regime

From a point of view temporal, contents in dissolved oxygen in water of Harreza dam (Table 4) are developing differently during the two years (P-value=0.005). Monthly average content of the first year is weaker (6.87±1.10 mg/l) than of the second year (7.16±1, 38 mg/l). The weakest rates are recorded in August in station S3 with 3.4 mg/l in 2009 and 2.4 mg/l in 2010, when highest rates are recorded in March 2009 in station S5 (8.8mg/l) and in February 2010 in stations S1 and S2 (8.9 mg/l). In terms of space, none significant difference exists between contents in dissolved oxygen of 5 stations (p-value=0.12).

Composition of Zooplanktonic Population

In total, 27 zooplanktonic species had been inventoried during both samplings years (Table 5): 8 species of cladocera belong to 5 families and 5 genera, 12 species of copepoda belong to 2 families and 7 genera and 8 species of rotifera belong to 5 families and 6 genera.

Temporal Structure

Specific richness (S) has declined during the two study years; it passed from 26 in 2009 to 24 in 2010 (Table 6). In samplings made in 2010, three zooplanktonic species were absent compared to those inventoried in 2009; It is about of *Chydorus sp.*, of *Polyarthra dolichoptera* Idelson, 1925 and of *Neolovenula alluaudi* Guerne & Richard, 1890. However, specie non inventoried in 2009 appeared in samplings of 2010: it is about of *Epiphanes senta* O.F. Müller, 1773.

Comparison of average relative abundance of zooplankton harvested during the two study years (Table 6) did not show any significant difference. (P-value=0.78). Structure of zooplanktonic population highlighted by index of Shannon-Weaver H' (Table 4), which gives more importance to rare species proves being more diversified in the 1st year (4.33 bits) than in 2nd year (4.29 bits). However, if we refer to Simpson's index (1-D) (Table 6), which gives more importance to abundant species, we notice that structure of zooplanktonic population is similar in both years (0.94). For that reason, calculation of Hill's index (1-Hill), which allows obtaining more exact view of observed diversity because sensitive at a time to rare species and to abundant ones (Table 6) shows a good diversity and varies from 0.78 for the 1st year to 0.77 for 2nd year. Pielou's index (Table 4) which is of 0.92 in 2009 and of 0.93 in 2010, expresses a good distribution of zooplanktonic population in both years.

Spatial Structure

Annual specific richness (S) is similar in the 5 stations of Harreza dam (Table 7): 26 in 2009 and 24 in 2010. Average relative abundance of zooplankton (Table 7) significantly different between the 5 stations (p-value < 0.0001).

During both years, it varies from 48± 31.3 ind/l to 81.75± 43.2 ind/l. It is maximal in station S5 with 81.75± 43.2 in 2009 and 77.92±48.62 ind/l in 2010, when it is minimal in station S1 with 50.17± 30.6 ind/l in 2009 and 48±31.3 ind/l in 2010. None significant difference is observed (p-value>0.05) for indexes of Shannon and Simpson of the 5 stations (Table 7). Index of Hill which sensitive to rare species and to abundant species proves that zooplankton diversity is similar in the 5 stations (p-value> 0.05). About equi-distribution of zooplankton species determined by index of Pielou (J'), none significant difference is noted between the 5 stations (p-value=0.41).

Frequencies of Occurrences and Dominances

Analysis of the occurrence frequency of sampled species in the 5 stations allowed classifying them in 5 constancy's levels (Table 8; Figure 2).

The first level is constituted of 2 omnipresent species met in 100% of samplings made during both years: cladocerans *B. longirostris* is met in stations S5 and S3 when copepods *D. castaneti major* is found only in station S5.

The second level contains 7 constant species present in 75 to 100% of samplings; it is about of cladocerans represented by *C. quadrangula*, *C. reticulata*, *B. longirostris* and of copepods represented by *D. castaneti major*, *C. strenuus strenuus*, *P. affinis*, *T. Prasinus.* Among sampled copepods *A. trajani* is constant only for the first year, when *C. strenuous strenuous* is constant only for the 2nd year.

The third level concerning frequent species present in 50 to 75% of samplings is formed of 13 species with 8 are met in all effected samplings during that two years, it is about of cladoceran *C. quadrangula*, of copepods represented by *C. strenuus strenuus*, *A. trajani*, *M. planus*, *T. prasinus* and of rotifèrs represented by *B. quadridentatus*, *K. quadrata*, *R. Rotatoria*. In the first year, there are only 3 frequent species which are *C. dubia, N. alluaudi* and *D. Cyaneus.* However, 2 species, *C. reticulata* and *P. affinis,* are frequent only in 2nd year.

The fourth level concerning common species met in 25 to 50% of samplings, is constituted by 18 species with 9 are found during the two years and are represented by *C. dubia, D. brachyurum, D. cyaneus, E. macruroides, P. fimbriatus, A. girodi*, *B. calyciflorus, K. valga* et *R. Rotatoria.* Seven species are found in the first year and are represented by *Chydorus sp., M. micrura, N. alluaudi, M. viridis viridis, M. minutus, P. dolichoptera, B. Quadridentatus.* On the other hand, 2 species are found only in the second year and are represented by *K. quadrata* et *E. Senta*.

The fifth and last level which concerns accessories species met in 5 to 25% of samplings is constituted of 9 species with 5 are found during both years, il is about of *M. micrura, M. viridis viridis, M. minutus, P. fimbriatus et A. Girodi*. However, 3 accessories species are met in 1st year, il is about o *Chydorus sp. E. macruroides P. dolichoptera* when in 2nd year, only *E senta* is present in our samplings.

Abundance level of species is linked with their constancy level. Omnipresent species are the ones the most abundant when accessories species are less abundant (Figure 2a, b).

DISCUSSIONS

The weak water levels recorded in Harreza, dam in reference of its initial capacity which is of 70 hm^3, are mainly induced by absence of water contribution by pumping because electric energy being very expensive.

The sole contributions of Harreza River which are characterized by weak and irregular flows, in 2009, dam was in

water deficit with monthly average volume of 3.68 ± 1.02 Hm^3 compared to year 2010 where contributions were more important with monthly average volume of 11.65 ± 4.58 Hm^3. Temperature evolution is similar in time and then has not been influenced by difference of water levels recorded between the two years. Superficial waters are influenced by air temperature and by radiative transfers received from sun and from atmosphere (Rodier, 1990; Westhoff et al., 2007).

Contents in dissolved oxygen recorded for the most part in stations during the two study years were favourable to aquatic biogenesis because they are above to the concentration of 4mg/l which is considered according to Lapointe (1977) and Légaré (1998) as a lower limit for survival and for protection of the whole living organisms. However, rates of 3.9mg/l and 2.4mg/m are recorded in August of the two years in station, S3 which particularises by its localisation in mouth zone of the lake, place in which sedimentation and deposit of organic matter are probably favoured. Consequently, microbial activity higher in summer caused by the last ones, explains these hypoxias (Rossetti et al., 2004, Kagalou et al., 2006). Evolution of monthly average content in dissolved oxygen passing from 6.87±1.10 mg/l in 2009 to 7.16±1.38 mg/l in 2010, is influenced particularly by growth of water volume recorded in the 2nd year.

As a matter of fact, principal component analysis (PCA) highlights existence of correlation on axe F2 (29.33%) between oxygen of both years and water volume of the 1st year (Figure 3). Hydrologic regime and water dynamic are known by their actions in process of ventilation and of oxygen dissolution (Makhoukh et al., 2011; Sadani et al., 2004; Rossetti et al., 2004)

Zooplanktonic population inventoried during the two study years are composed of 27 species. Specific richness (S) has declined from 26 in 2009 to 24 in 2010 where 3 species (*Chydorus sp*., *Polyarthra dolichoptera* and *Neolovenula alluaudi*) disappeared from our samplings, when another specie non inventoried by the past has appeared (*Epiphanes senta*).

According to abiotic measures which we have performed, this regressing of specific richness coincides with growth of water contribution recorded during the 2nd year. Effectively, precipitations, wind, where cloudiness, are identified as being critical factors in zooplankton’s development (Dejen et al., 2004). High cloudiness, which would result of water level growth, would explain appearance of *E. senta* which is typical to waters strongly loaded with organic matter (Hall et al., 1976). Contrary to that, regressing of specific richness observed during the 2nd year by disappearance of the 3 species quoted, could be linked to others physico-chemical factors or biological ones as predatory and competition (Okogvu, 2009; Onwudinjo et al., 1994; Ovie et al., 1994).

Quality of water brought during the 2nd year and present abiotic conditions would allow abundance regulation of zooplanktonic population and they are acting to be to the same level that one of the 1st year. The answer brought by analyse of PCA (Figure 3) highlights existence of correlation on axe F1 (43.31%) between abundance and growth of water volume during the 2nd year. As a matter of fact, abundance of aquatic invertebrates is linked to rising of lakes water level which results submersion of littoral zones favouring distribution of nutrients and hatching of resting eggs (Dejen et al., 2004; Mergeay et al., 2006).

Structure homogeneity of zooplanktonic population during the two years is confirmed by index of Hill (0.78 in 2009 and 0.77 in 2010) and index of Pielou (0.92 en 2009 and 0.93 en 2010). This structure of diversity is proving to be homogeneous in the space, during the two years, since we have not noted none significant difference between indexes of Hill (p-value= 0.40) and index of Pielou (p-value=0.41) in the 5 stations. Nevertheless, in spite of the small surface of

Harreza dam and its simple morphology, heterogeneity of the abundance of the zooplanktonic populations is noted between stations (p-value < 0, 0001).

At small scale, where abiotic conditions are considered as similar in space (White 1998 : Burks et al., 2002), heterogeneity of spatial distribution of zooplanktonic population is particularly influenced by biotic processes (Pinel-Alloul, 1995 ; Thackeray et al., 2004), notably linked to predatory practised by vertebrates as fish (White,1998; Lauridsen et al., 1999; Romare et al., 2003). That situation explains a maximal abundance in station S5 which takes place in central zone of the lake where predatory gradient seems being reduced by opposition to statio n S1, where abundance is minimal and which characterizes by its location on shores in littoral zone, in the same way as others stations in which predatory gradient could be more important.

This spatial heterogeneity is also confirmed by constancy of species: The omni presents, represented by cladocerans and copepods are the most abundant in station S5 and exceptionally in station S3 during the 1st year, when rare species are less abundant and are majority in station S5 during the 2nd year with 62.50% of population when they are absent during the 1st year in the same station.

CONCLUSIONS

Obtained results from the two study years, reveal that hydrologic regime of Harreza dam is irregular in the time. With absence of water contribution by pumping, flows of Harreza River determine hydrologic regime of this dam.

Difference of water levels recorded between the two years, 2009 and 2010 did not affect evolution of the temperature. Contents in dissolved oxygen (> 4mg/l) are favourable to aquatic life. Waters contributions favour growth of contents in dissolved oxygen passing from 6.87±1.10 mg/l in 2009 to 7.16±1.38 mg/l in 2010. Hydrologic regime of Harreza dam influences zooplanktonic diversity.

Water contributions provoked disappearance of 3 species (*Chydorus sp., Neolovenula alluaudi* and *Polyarthra dolichoptera)* and appearance of other specie *(Epiphanes senta)*. Structure of zooplanktonic population is not affected by the difference of hydrologic regime of the two years. Cladocera *Bosmina longirostris* O.F. Müller, 1785 and copépod *Diaptomus castaneti* major Dussart, 1957 characterize zooplanktonic population of Hrreza dam by their omnipresence. Spatial disparity of abundance levels, noted during the two years, is linked neither to hydrologic regime nor to abiotic factors which prove being homogeneous but too much more to biotic factors such as zooplanktonophagy.

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APPENDICES

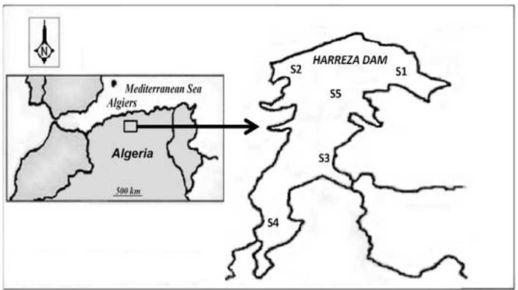
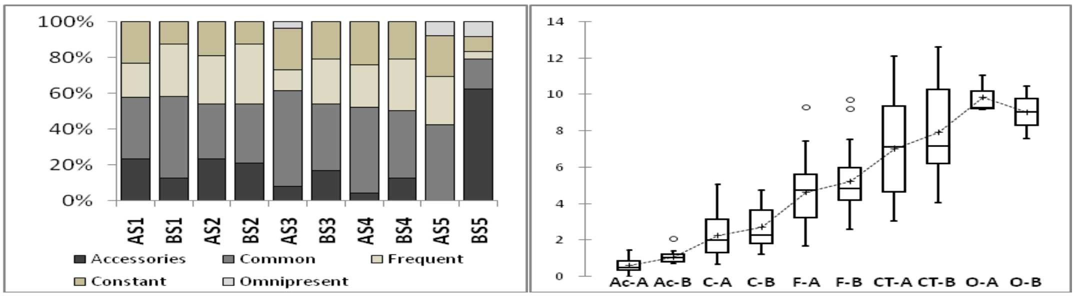


Figure 1: Geographical Situation of Harreza Dam (Algeria) and Localization of the Sampling Stations



(a) (b)

Figure 2: Constancy Level of Zooplankton Species (a) and Variability of their Abundances (b)

(AS): stations of 1 to 5 in 2009; BS: stations of 1 to 5 in 2010) (Ac: Accessories species; C: common species; F: frequent species; C: constant species; O: omnipresent species; - A: year 2009; - B: year 2010

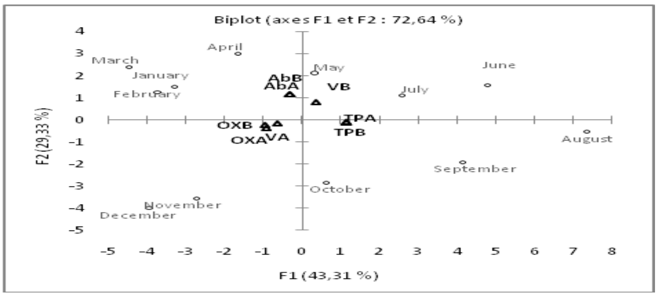


Figure 3: Results of the Principal Component Analysis (PCA); with Axis F1 (43, 31%) and F2 (29, 33%). Annual Abundance of the Zooplanktonic Species (AbA : 2009 ; AbB : 2010), Dissolved Oxygen (OXA : 2009 ; OXB : 2010), Temperature (TPA : 2009 ; TPB : 2010), Water Volume (VA : 2009 ; VB : 2010)

Table 1: Morphometric and Hydrological Characteristics of Harreza Dam

Date of commissioning	1984
Initial capacity of dam	70 Hm^3
Inter-annual average distribution of pouring basin	30.8 Hm3
Initial capacity of dam	70 Hm3
Regulated volume	23.00 Hm3/an
Silting rate	1 %
Surface of pouring basin	143 Km^2

Table 2: Water Reserves Recorded between 2009 and 2010 in the Harreza Dam

Year	Volume Hm3/ Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2009	3.415	3.443	3.809	3.893	4.154	3.309	3.736	2.782	1.643	3.543	4.519	5.96	3.68±1.02
2010	8.781	8.965	13.235	17.624	18.826	13.487	17.525	11.348	9.796	8.998	6.96	4.239	11.65±4.58

Table 3: Temperatures Statements (C°) Monthly of Water of Harreza Dam, by Station and by Year

Month	Stations – Year (2009)					Stations – Year (2010)				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
January	10.5	10.2	9.5	10.2	10.2	10.8	10.7	10.6	10.7	10.1
February	10.3	10.8	10.3	10.9	10.3	9.6	9.7	9.4	9.6	9.4
March	9.5	9.9	9.3	9.5	9.3	9.1	9.2	9.2	9.3	8.9
April	15	15.8	15.2	15.3	15	14.3	14.6	15.1	14.9	14.7
May	22	21.9	21.1	20.9	21	21.9	21.9	21.7	21.6	21
June	25.5	26	26.7	25.5	25.2	24.6	25.3	26.1	25.9	25.2
July	23	23.1	23.4	22.9	22.6	22.4	24.3	24.4	24.9	23.8
August	27.6	29.7	29.1	29.2	29.2	27.9	28.4	28.3	28.2	28.1
September	26	26.3	26.9	26.8	26.3	25.2	25.4	25.7	26.2	25.9
October	21	21.3	21.5	21.6	21.2	20.2	20.3	21	20.6	20.2
November	12	11.9	11.3	11.4	11.2	14.3	14.1	14.3	14.4	13.8
December	11	11.9	11	10.8	11.1	10.8	10.9	11	11	10.7

Table 4: Dissolved Oxygen Statements (mg/l) of Water of Harreza Dam by Station and by Year

Month	Stations – Year (2009)					Stations – Year (2010)				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
January	7.3	7.5	7.2	7.3	7.8	7.6	7.4	7.9	7.2	7.7
February	7.4	7.2	6.7	7.2	7.6	8.9	8.9	7.6	7.9	8.3
March	7.9	8.1	7.9	7.4	8.8	8.5	8.7	7.8	7.9	7.8
April	7.1	7.3	7.2	7.3	7.1	7.4	7.9	7.2	7.8	7.7
May	7.1	7.2	7.1	6.8	7.2	7.4	7.9	7.5	7.8	7.6
June	4.9	5.1	4.7	5.1	5.9	5.9	5.4	4.6	5.2	5.6
July	6.4	6.5	6.1	6.3	6.7	6.8	6.4	6.6	6.3	6.9
August	4.3	4.4	3.1	4.2	5.7	5.2	5.1	2.4	4.2	6.7
September	7.4	7.5	7.3	6.9	7.1	7.3	7.4	2.4	6.2	7.4
October	7.3	7.2	7.1	7.3	7.9	7.8	7.1	7.3	7.9	8.1
November	7.8	7.6	7.6	7.1	7.9	8.8	8.4	7.6	8.3	8.2
December	7.3	7.2	7.4	7.6	7.7	7.7	8.1	7.7	7.9	8.6
Monthly Average	**6.87±1.10**					**7.16±1.38**				

Table 5: Zooplankton Populations of Harreza Dam, by Station and by Year

Species		Year 2009	Year 2010
Cladocera			
Daphniidae	*Ceriodaphnia quadrangula* O.F. Müller, 1785	+	+
	Ceriodaphnia dubia Richard, 1894	+	+
	Ceriodaphnia reticulata Jurine, 1820	+	+
Chydoridae	*Chydorus sp.*	+	
Sididae	*Diaphanosoma brachyurum* Liévin, 1848	+	+
Bosminidae	*Bosmina longirostris* O.F. Müller, 1785	+	+
Moinidae	*Moina micrura* Kurz, 1875	+	+
Copepoda			
Diaptomidae	*Neolovenula alluaudi Guerne & Richard, 1890*	+	
	Diaptomus cyaneus Gurney, 1909	+	+
	Diaptomus castaneti major Dussart, 1957	+	+
Cyclopidae	*Cyclops strenuus strenuus* Fischer, 1851	+	+
	Acanthocyclops trajani Mirabdullayev & Defaye, 2004	+	+
	Eucyclops macruroides Lilljeborg, 1901	+	+
	Megacyclops viridis viridis Jurine, 1820	+	+
	Metacyclops minutus Claus, 1863	+	+
	Metacyclops planus Gurney, 1909	+	+
	Paracyclops affinis Sars, 1863	+	+
	Paracyclops fimbriatus Fischer, 1853	+	+
	Tropocyclops prasinus Fischer, 1860	+	+
Rotifera			
Synchaetidae	*Polyarthra dolichoptera* Idelson, 1925	+	
Asplanchnidae	*Asplanchna girodi* De guerne, 1888	+	+
Brachionidae	*Brachionus calyciflorus* Pallas, 1776	+	+
	Brachionus quadridentatus Hermann, 1783	+	+
	Keratella valga Ehrenberg, 1834	+	+
	Keratella quadrata Müller, 1786	+	+
Philodinidae	*Rotaria rotatoria* Pallas, 1766	+	+
Epiphanidae	*Epiphanes senta* O.F. Müller, 1773		+

Table 6: Annual Indexes of Zooplanktonic Diversity of the Harreza Dam

Indixes/Year	Specific Richness (S)	Average Relative Abundance (Ind/l)	Shannon (H' en bit)	Simpson (1-D)	Hill (1-Hill)	Piélou (J)
2009	26	80.22±15.65	4.33	0.94	0.78	0.92
2010	24	77.46±15.41	4.29	0.94	0.77	0.93

Table 7: Indexes of Zooplanktonic Diversity of the Harreza Dam, by Station and by Year (A1: 2009; A2: 2010)

Indexes	Stations/Year									
	S1		S2		S3		S4		S5	
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
Shannon (H') (Bit)	4.15	4.26	4.32	4.29	4.33	4.25	4.33	4.28	4.38	4.3
Simpson (D)	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06
Simpson (1-D)	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.95	0.94
Hill	0.23	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.24
1-Hill	0.77	0.76	0.76	0.76	0.77	0.77	0.77	0.77	0.77	0.76
Piélou (J)	0.85	0.87	0.88	0.87	0.88	0.87	0.88	0.87	0.89	0.88
Abondance relative(P)	50.17± 30.6	48± 31.3	57.17± 35.07	54.33± 35.79	69.33± 38.79	68.67± 46.95	75.83± 42.71	73.83± 49.14	81.75± 43.2	77.92± 48.62
Richesse spécifique (S)	26	24	26	24	26	24	26	24	26	24

Table 8: Frequencies of Occurrences of Zooplankton Species of Harreza Dam, by Station and by Year (A1: 2009; A2: 2010)

Species	Stations/Year									
	Station S1		Station S2		Station S3		Station S4		Station S5	
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
C. quadrangula	75.00	50.00	66.67	50.00	75.00	66.67	83.33	83.33	83.33	83.33
C. dubia	33.33	41.67	33.33	41.67	33.33	33.33	33.33	33.33	66.67	41.67
C. reticulata	75.00	66.67	75.00	75.00	75.00	75.00	75.00	75.00	75.00	0.00
Chydorus sp.	8.33	0.00	16.67	0.00	16.67	0.00	33.33	0.00	41.67	0.00
D. brachyurum	33.33	33.33	33.33	33.33	33.33	33.33	41.67	33.33	41.67	33.33
B. longirostris	75.00	91.67	83.33	91.67	100.00	91.67	91.67	91.67	100.00	100.00
M. micrura	25.00	16.67	16.67	8.33	25.00	16.67	25.00	16.67	25.00	16.67
N. alluaudi	58.33	0.00	66.67	0.00	41.67	0.00	58.33	0.00	66.67	0.00
D. cyaneus	33.33	41.67	33.33	25.00	41.67	33.33	41.67	41.67	50.00	41.67
D. castaneti major	91.67	83.33	75.00	83.33	91.67	83.33	91.67	83.33	100.00	100.00
C. strenuus strenuus	50.00	66.67	41.67	66.67	58.33	66.67	58.33	66.67	75.00	75.00
A. trajani	66.67	50.00	75.00	66.67	75.00	58.33	75.00	66.67	75.00	66.67
E. macruroides	16.67	25.00	25.00	33.33	25.00	25.00	8.33	25.00	25.00	33.33
M. viridis viridis	16.67	16.67	8.33	16.67	8.33	16.67	25.00	16.67	25.00	16.67
M. minutus	8.33	8.33	16.67	16.67	25.00	16.67	25.00	8.33	25.00	16.67
M. planus	58.33	58.33	58.33	58.33	58.33	50.00	66.67	66.67	66.67	66.67
P. affinis	83.33	58.33	83.33	66.67	91.67	75.00	75.00	66.67	83.33	83.33
P. fimbriatus	16.67	33.33	25.00	16.67	33.33	25.00	33.33	25.00	33.33	33.33
T. prasinus	75.00	75.00	66.67	66.67	83.33	83.33	75.00	75.00	83.33	83.33
P. dolichoptera	16.67	0.00	16.67	0.00	25.00	0.00	33.33	0.00	33.33	0.00
A. girodi	25.00	25.00	16.67	25.00	25.00	25.00	25.00	16.67	25.00	25.00
B. calyciflorus	33.33	41.67	33.33	41.67	33.33	41.67	33.33	41.67	41.67	41.67
B. quadridentatus	33.33	50.00	50.00	50.00	41.67	50.00	50.00	50.00	50.00	50.00

Table 8: Contd.,

K. valga	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33
K. quadrata	58.33	41.67	58.33	33.33	50.00	41.67	58.33	50.00	66.67	58.33
R. rotatoria	41.67	41.67	50.00	50.00	41.67	58.33	50.00	58.33	58.33	58.33
E. senta	0.00	25.00	0.00	16.67	0.00	16.67	0.00	25.00	0.00	25.00